Korean J. Ecology 5(4) : 137~142, 1982

Physiolgical and Ecological Studies of the Vegetation on Ore Deposits

3. Radioecological Symptoms of Plants over Uranium Ore Deposits in Koisan, Korea

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金屬鑛物上에 나타나는 植物에 관한 生理生態學的 硏究

3. 槐山 우라늄鑛地帶 植物의 放射線生態學的 徵狀

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ABSTRACT

From 1975 to 1981, the survey was carried out to find out radioecological effects of uranium ore deposits on natural vegetation in Koisan, Korea. The symptoms of spotty and mosaic chlorosis, and necrosis were observed in flowering plants in the areas of uranium ore deposits at Deok-Peung-Ri A, B, and C in Koisan.

Although 13 species were found to be chlorosis and necrosis, foliages observed are small and very rare. The features of these symptoms closely resemble those occured by the effects of heavy metals.

The amount of transparent radiation throughout the depth of soils from uranium radiation sources decreases exponentially. The mean contents in leaves of spotty and mosaik chlorotic plants, and soils were 1.36 ~1.53 and 5.3~7.4ppm, respectively.

INTRODUCTION

Plants may respond to their edaphic environments by showing characteristic variations in their morphological, ecological and physiological features. The features of the symptoms of plants growing in uranium ore deposits closely resemble those caused by effects of heavy metals and are characteristic of the mature leaves. The interveinal areas of the leaf show the pattern of mosaic while the cells adjacent to the veins remain green.

Color changes in flower are usually the result of either radioactivity or the presence of certain elements in the soils. Shacklette(1964) has observed extensive flower variation of ***Epilobium angustifolium*** growing in Canada over uranium deposits adjacent to those described.

The concentration range of essential elements in plants would be narrower than that of uranium because of regulatory mechanisms which tent to keep the amounts of essential elements relatively constant in plants. Goldschmidt(1937) reported that mean uranium concentrations in plants and igneous rocks were 0.05 and 2.6 ppm, respectively. Whitehead and Brooks(1969) have reported uranium values ranging from 1.5 to 1000 ppm in the ash of the New Zealand shrub, ***Coprosma australis***.

This paper is an account of a survey of Koisan over uranium ore deposits in Korea carried out during the period 1975~81.

MATERIALS AND METHODS

1. Survey method

A care was taken to distinguish characteristic features from symptoms of fungal, virus and insect attack. Records were included only where drop or mosaik chlorosis was pronounced and occurred with the severity ın the mature foliage. In 1975~81, observations were confined to areas uranium ore deposits of Koisan and were replicated in greater detail and lists of species of radioecological variations were obtained.

The survey was extended to include the vegetation in the areas of uranium ore deposits in Koisan. The position of the sites at which lists of drop and mosaik chlorotic species were collected is shown in Fig. 1.

2. Chemical analysis of soils and plants

Uranium ore in Koisan contains 0.049% of U_3O_8 and irradiates 126~255 cpm, which are detected by G-M counter, on the suface soils.

Soils were sampled in duplicate from areas about $1m^2$ which seemed uniform and typical for the site. Samples were taken A_1 horizon from four places within the square, there was a superficial layer of stones or plants and roots which were removed before sampling. All analyses were carried out in duplicate on an air-dried fraction of the sample and on a fraction that had passed through a standard 2mm sieve.

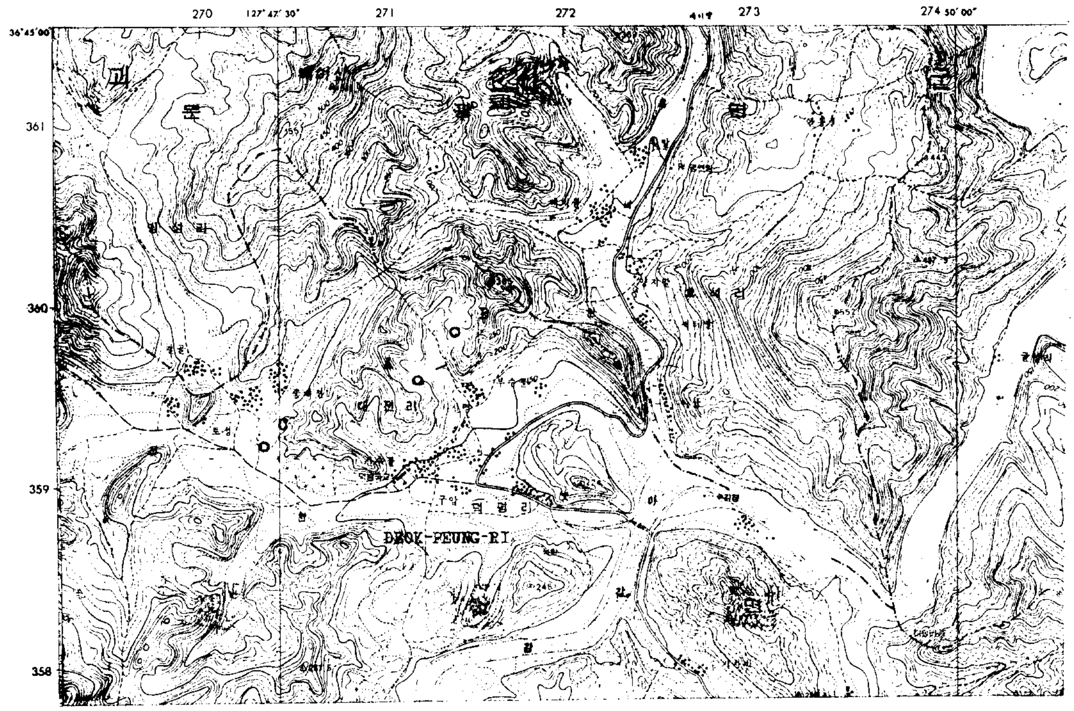

Fig. 1. Map showing the areas of the uranium ore deposits at Koisan in Korea.

Soil pH was determined in a 1:2.5 soil/distilled water mixture. Total nitrogen in soils was determined by the micro-Kjeldahl method. Exchangeable cation and hydrogen were analysed by the methods of Brown(1943). Exchangeable K, Na, Ca, Mg and Zn were extracted by 1 N ammonium acetate solution of pH 7.00 and determined by flame photometer and atomic absorption spectrophotometer. Available phosphorus was extracted with Truogs reagent and analysed by spectrophotometer. Radiation irradiated in soils and on the soil surface was detected by G-M counter.

3. Chemical analysis of plants

The contents of chlorophyll and carotenoid in the normal and chlorotic fresh leaves of plants in the areas of the uranium ore deposits were determined by the method of Mackinny(1941). Plant samples were collected from the sites of the uranium ore deposits. The plant material was bulked and thus only one collection from each site was analysed. The materials were rinsed in distilled water. Leaves and stems were separated from the plants and oven-dried at 105°C. These materials were ashed in a mixture of nitric and perchloric acids. The analyses of P, of K and of Ca, Mg and U were carried out by spectrophotometry, flame photometry, and atomic absorption spectrophotometry, respectively. The nitrogen contents of the materials were determined by the micro-Kjeldahl method.

RESULTS AND DISCUSSION

1. A feature of vegetation

Spotty and mosaic chlorotic plants were frequently observed in the vegetation of the sites of the uranium ore deposits during the period from May to October. The proportion of foliage affected was very small although spotty chlorosis was severe(Photo. 1-6) and spotty necrosis was in old leaves(Photo. 7).

As shown in Table 1, chlorotic plants in vegetation at Deok-Peung-Ri A, B and C were 6, 3 and 7 species of flowering plants. In three areas at Deok-Peung-Ri, plants of spotty chlorosis were shown in 13 species.

Chung(1965) reported that exceeding Zn ion showed yellow color of leaf tips of *Digitaris sanguinalis* var. *cilialis* and in the cases of lead and copper occurred chlorotic symptoms with reddish spots of the leaves of *Chenopodium album* var. *centrorubrum* and *Echinochloa crusgalli*. It is also apparent that the observations of chlorotic sign are consistent with results obtained by Chung(1965). Therefore, the features of the symptoms of plants growing on soils of uranium ore deposits closely resemble those occured by the effects of Zn, Pb and Cu.

Table 1. A comparison of the incidence of chlorosis in areas of the uranium ore deposits in three areas of Deok-Peung-Ri

Species	Deok-Peung-Ri A	B	C
Artemisia asiatica	+	−	+
Artemisia mongolika	−	−	+
Arundinella hirta	+	+	−
Callicarpa japonica	−	−	+
Commelina communis	−	−	+
Erigeron annuus	−	+	−
Palura chinesis	−	−	+
Rubia Akane	+	−	−
Rubus parvifolius	−	−	+
Rubus crataegifolius	+	+	−
Salix koreensis	+	−	−
Smilax china	+	−	−
Trifolium repens	−	−	+

2. Chlorosis and necrosis

Mosaik chlorosis of *Trifolium repens*, *Commelina communi* and *Artemisia asiatica*, and spotty chlorosis of *Arundinella hirta*, *Rubus crataegifolius* and *Smilax china* were often severely apparent in mature leaves. The shrub such *Palura chinesis* was subject to a mosaik pattern of yellow green and green. The radioecological aspect of severe chlorosis was frequently observed as a necrosis sign.

The comparison of the contents of chlorotic and normal foliages of several plants in the areas of uranium ore deposits are set out in Table 2. The contents of chlorophyll a and b in the severely chlorotic leaves were about half in the normal leaves and carotenoid contents were lower than those in the normal. It suggests that spotty and mosaik chlorosises show decrease responses of chlorophyll and carotenoid contents in plant leaves. In this vegetation

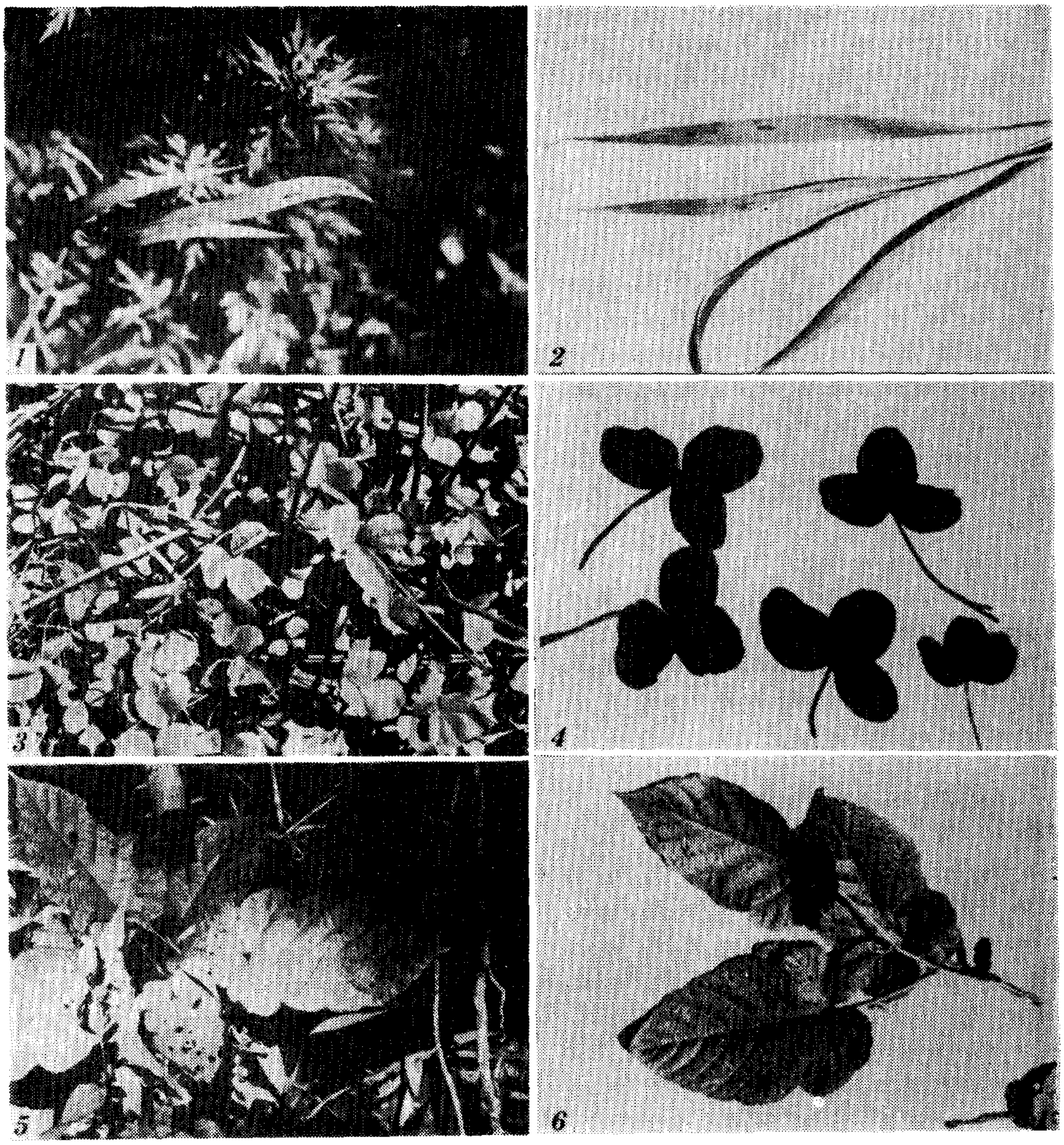

Photo. 1~6. Explanation of photograph.
1~2. Spotty chlorosis in *Arundinella hirta* from vegetation in Deok-Peung-Ri A,
3~4. Mosaic chlorosis in *Trifolium repens* from vegetation in Deok-Peung-Ri C,
5~6. Spotty chlorosis in *Rubus crataegifolius* from vegetation in Deok-Peung-Ri B.

on the uranium ore deposits, there is the same sign of plant leaves to heavy metals with the sign of these same species in a pot experiment made on the heavy metal treatments(Chung, 1965). Shacklette (1964) has observed flower variation of *Epilobium angustifolium* growing in Canada over uranium ore deposits adjacent to these described.

3. Chemical properties of plants on soils of uranium ore deposits

The use of rock analysis is misleading. Rock analyses do not accurately represent the elements available to plants which grow on soils. Therefore,

Table 2. The comparison of the amount of chlorophyll and carotenoid in the normal and chlorotic fresh leaves of plants in the areas of uranium ore deposits in Deok-Peung-Ri

Species		Chlorophyll a (mg/10g)	Chlorophyll b (mg/10g)	Chlorophyll a : Chlorophyll b	Total Chlorophyll (mg/10g)	Total carotenoid (mg/10g)
Artemisia asiatica	Normal	7.64	4.61	1.7 : 1	12.25	2.47
	Chlorosis	3.70	2.77	1.4 : 1	6.47	1.87
Callicarpa japonica	Normal	4.21	2.28	1.9 : 1	6.49	1.51
	Chlorosis	2.01	1.16	1.8 : 1	3.17	1.20
Commelina cammunis	Normal	6.85	4.66	1.5 : 1	11.51	1.76
	Chlorosis	2.67	1.69	1.6 : 1	4.36	1.48
Rubus parvifolius	Normal	6.20	3.80	1.7 : 1	10.00	1.87
	Chlorosis	3.06	1.74	1.8 : 1	4.80	1.57
Trifolium repens	Normal	8.25	6.17	1.4 : 1	14.42	2.60
	Chlorosis	4.38	2.75	1.6 : 1	7.14	1.82

Table 3. Chemical analyses of soils in the areas of uranium ore deposits at Deok-Peung-Ri

Components	Areas		
	A	B	C
Organic materials(%)	5.3	7.3	5.2
Soil pH	5.80	5.68	5.87
Exchangeable hydrogen (meq/100g)	8.81	6.16	3.39
Exchangeable cation (meq/100g)	6.38	7.48	9.91
Total nitrogen(%)	0.21	0.22	0.19
Available P(ppm)	24.6	14.9	19.2
Exchangeable K(ppm)	97	125	136
Exchangeable Ca(ppm)	90	120	366
Exchangeable Mg(ppm)	16	20	77
Exchangeable Na(ppm)	106	134	98
Uranium(ppm)	7.3	8.8	12.4

Table 3 gives data of the mineral nutrient contents available to plants but uranium contents are the total amount in soils. The amount of transparent radiation throughout the depths of soils from uranium radiation sources(Fig. 2) shows that radiation activity, CPM, decreases exponentially. Radiation activity of 255 CPM of uranium ore deposits decreased to 50 CPM on 100cm depth of soils. The soil horizen of 100cm depth is Aoo to C soil layers and contains plant roots.

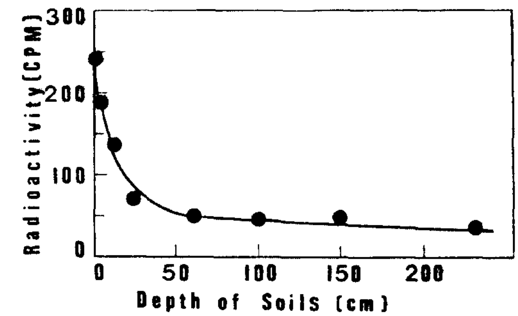

Fig. 3. The amount of transparent radiation according to the depths of soils.

Chemical properties of soils on the uranium ore deposits at Deok-Peung-Ri were presented in Table 3. Organic matter, soil pH, exchangeable hydrogen, exchangeable cation, total N and available P were 5.3~7.3%, 5.68~5.87, 3.39~8.81meq/100g, 6.38~9.91meq/100g, 0.19~0.22% and 14.9~24.6ppm, respectively. The contents of exchangeable K, Ca, Mg and Na were 97~136, 90~366, 16~77 and 98~134ppm. The uranium level was 7.3~12.4ppm. Under these soil conditions, the chemical composition of the chlorotic leaves of plants are shown in Table 4.

As shown in Table 4, N, P, K, Ca, Mg and Na

Table 4. Inorganic components of chlorotic plants in the areas of uranium ore deposits at Deok-Peung-Ri

Species	N(%)	P(ppm)	K(%)	Ca(ppm)	Mg(ppm)	Na(ppm)	U(ppm)
Artemisia asiatica(L)	1.96	475	3.32	725	198	826	1.45
Callicarpa japonica(L)	1.44	233	2.15	650	225	1651	1.36
(S)	1.19	261	2.25	775	200	472	1.44
Rubus parvifolius(L)	1.89	366	2.25	1650	595	1651	1.53

*L: Leaves, S: Stems

contents in *Artemisia asiatica*, *Callicarpa japonica* and *Rubus parvifolius* were 1.19~1.96%, 233~475%, 2.15~3.32%, 650~1650ppm, 198~595ppm and 826~1651ppm, respectively. However, severe chlorotic leaves contain uranium of 1.36~1.53ppm in ash.

Goldschmidt(1937) reported that mean concentrations in plants and igneous rocks were 0.05 and 2.6ppm, respectively. Whitehead and Brooks(1969a) have reported uranium values ranging from 1.5 to 1000ppm in the ash of the New Zealand shrub *Coprosma australis*. According to Whitehead and Broocks (1969b), uranium concentrations in Bryophytes in ash, peat absorbers in ash and stream waters from the lower Buller Gerge Region of New Zealand were 4.0~3240.0ppm, 0.65~3.25ppm and 0.7~86.0 ppm, respectively. It suggests that nonessential elements such as uranium in plants were absorbed as a function of the soil content of the elements and damaged by radiation.

摘 要

충청북도 괴산군 청천면 덕평리의 우라늄광지대에 나타나는 植物徵狀을 放射線生態學的으로 調査(1975~81)하였다.

本鑛地帶의 植物은 點 혹은 斑點의 白化現象이 일어나고 심한 경우에는 그 部分만이 말라죽는 현상이 관찰되었다. 이러한 白化現象이 일어나는 植物은 13種이었다.

放射線의 투과는 土壤의 깊이에 따라 指數函數的으로 감소하였으며 白化現象이 나타난 植物의 잎과 이 지대의 토양의 우라늄含量은 各各 1.36~1.53ppm과 5.2~7.4ppm이었다.

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(*Received September 18, 1982*)